Method of Test for

DETERMINATION OF SPECIFIC GRAVITY AND DENSITY CHARACTERISTICS OF COMPRESSED ASPHALTIC MIXTURES

DOTD Designation: TR 304-03

I. Scope

A. This method of test is intended to determine the bulk specific gravity (G_{mb}) and density characteristics of specimens of asphaltic mixtures made with low absorptive aggregates. Density characteristics include theoretical maximum specific gravity (G_{mm}), % voids, density of mixture, % VMA, %VFA, and pavement density.

B. Reference Documents
   1. DOTD TR 300 – Determination of Bulk Specific Gravity of Aggregate and Mineral Filler for Asphaltic Mixtures.
   2. DOTD TR 305 – The Stability and Flow of Asphaltic Concrete Mixtures – Marshall Method.
   3. DOTD TR 327 – Theoretical Maximum Specific Gravity of Asphaltic Concrete Mixtures.
   4. AASHTO T 166 – Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens.

II. Apparatus

A. **Balance** – having a capacity of 2kg or more and sensitive to 0.1 g.

B. **Basket or hanger device** – No. 4 mesh basket or other approved, non-corrosive device for holding the specimen.

C. **Water Bath** – minimum 5-gal plastic or water tight, non-corrosive container filled with water, equipped with an overflow device to maintain a constant water level and capable of maintaining a water temperature of 77±1.8°F (25±1°C).

D. **Oven** – capable of maintaining a temperature of 125±5°F (52±3°C).

E. **Suspension apparatus** – a non-absorptive, non-corrosive device suitable for suspending the basket device from center of scale pan (Figure 1).

F. **Absorptive material** – for drying specimens.

G. **Asphaltic Concrete Plant Report** – DOTD Form No. 03-22-3085 (Figure 2).

H. **Asphaltic Concrete Pavement Report** – DOTD Form No. 03-22-3080 (Figure 3).

I. **Personal Protective Equipment** – thermal gloves, eye protection, apron, tongs and other tools for handling hot materials.

III. Health Precautions

Proper precautions are to be taken whenever hot materials or equipment must be handled. Use container holder or thermal gloves while handling hot containers. Wear eye protection while stirring and weighing heated materials due to possible shattering of particles. Dry contaminated materials under a vent to prevent exposure to fumes.

IV. Sample

The sample shall consist of one or both of the following:

A. Briquettes molded in accordance with DOTD TR 305 or AASHTO TP4.

B. Pavement cores taken in accordance with appropriate requirements.

V. Procedure

A. Clean the specimen by wiping it with absorptive material. Place the specimen in the oven set at 125 ± 5°F

(52 ± 3°C) and dry specimen to a constant mass. After constant mass is obtained, cool the specimen to room temperature at 77±1.8°F (25±1°C). Recently molded laboratory briquettes or specimens that have not been exposed to moisture do not require drying.

Note 1: *Constant mass is defined as the mass at which further drying at 125 ± 5°F (52 ± 3°C) does not change the mass by more than 0.05 percent in subsequent weighings at two-hour intervals. Recently molded laboratory samples which have not been exposed to moisture do not require drying.*

B. Molded Briquette

1. Determine the specific gravity of the molded briquette.
   a. Check balance for zero reading prior to weighing.

Note 2: *Balances should be checked for zero prior to obtaining any weight.*

   b. Weigh the briquette in air to the nearest 0.1 g. Record on Asphaltic Concrete Plant Report as **A**.
   c. Place briquette in basket device, immerse in water at 77±1.8°F (25±1°C) for 4 ± 1 minutes, weigh to the nearest 0.1 g and record on the Asphaltic Concrete Plant Report as **B**. When weighing in water, no manipulation of the briquette or container is allowed. (See Figure 1)
   d. Remove the specimen from the water. Damp-dry the specimen as quickly as possible by blotting with a damp towel. Immediately weigh the briquette to the nearest 0.1 g and record as the saturated surface dry mass, **C**.
   e. Determine the bulk specific gravity of the briquette in accordance with Step VI.A.1 and record as **D** on the Asphaltic Concrete Plant Report.
2. Determine the density of the briquette in accordance with Step VI.A.2 and record as **E** on the Asphaltic Concrete Plant Report.
3. Determine the average theoretical maximum specific gravity, G_{mm}, of the mixture in accordance with Step VI.A.3 and record as **F** on the Asphaltic Concrete Plant Report.
4. Determine the percent theoretical maximum specific gravity (%G_{mm}) in accordance with Step VI.A.4 and record as **G** on the Asphaltic Concrete Plant Report.
5. Determine the percent voids (V_a) in accordance with Step VI.A.5 and record as **H** on the Asphaltic Concrete Plant Report.
6. Determine the percent voids in mineral aggregate (%VMA) in accordance with Step VI.A.6 and record as **J** on the Asphaltic Concrete Plant Report.
7. Determine the percent voids filled with asphalt (%VFA) in accordance with Step VI.A.7 and record as **K** on the Asphaltic Concrete Plant Report.

C. Pavement Core

1. Determine the bulk specific gravity of the pavement core.
   a. Check balance for zero reading prior to weighing.
   b. Weigh pavement core in air to the nearest 0.1 g and record as **A** on the Asphaltic Concrete Pavement Report.
   c. Place pavement core in basket device, immerse in water at 77±1.8°F (25±1°C) for 4±1 minutes, weigh to the nearest 0.1 g and record as **B** on the Asphaltic Concrete Pavement Report. When weighing in water, no manipulation of the pavement core ore container is allowed.
   d. Remove the specimen from the water, damp-dry the specimen

as quickly as possible by blotting with a damp towel and determine the surface dry mass as "**C.**"

e. Determine the bulk specific gravity of the pavement core in accordance with Step VI.B.1 and record as **P** on the Asphaltic Concrete Pavement Report.

2. Record the average theoretical maximum specific gravity, determined in Step V.B.3, as G_{mm} on the Asphaltic Concrete Pavement Report.
3. Determine the % pavement density in accordance with Step VI.B.2 and record as **PD** on the Asphaltic Concrete Pavement Report.
4. Determine the average % pavement density for the lot in accordance with Step VI.B.3 and record as "**Avg. Pavement Density for Lot**" on the Asphaltic Concrete Pavement Report.

VI. Calculations

A. Molded Briquette

1. Calculate the bulk specific gravity of the briquette, **D**, to the nearest 0.001 using the following formula:

$$D = \frac{A}{C - B}$$

where:

A = wt. of briquette in air, g
B = wt. of briquette in water, g
C = wt. of SSD briquette

example:

A = 1209.3
B = 704.0
C = 1210.2

$$D = \frac{1209.3}{1210.2 - 704.0}$$

$$= \frac{1209.3}{506.2}$$

$$= 2.38897$$

$$D = 2.389$$

2. Calculate the density of the mixture, **E**, to the nearest 0.1 (lb/ft³) using the following formula:

$$E = D \times 62.4$$

where:

D = bulk specific gravity of briquette, G_{mb}
62.4 = constant

example:

D = 2.389

$$E = 2.389 \times 62.4$$
$$= 149.073$$
$$E = 149.1 \text{lb/ft}^3$$

3. Calculate the average theoretical maximum specific gravity (G_{mm}), **F**, to the nearest 0.001 using the following formula:

$$F = \frac{G_{mm1} + G_{mm2}}{2}$$

where:

G_{mm1} = first theoretical maximum specific gravity for the lot (determined in accordance with TR 327)
G_{mm2} = second theoretical maximum specific gravity for the lot (determined in accordance with TR 327)
2 = constant (equals number of sample sets obtained per lot)

example:

G_{mm1} = 2.486
G_{mm2} = 2.494

$$F = \frac{2.486 + 2.494}{2}$$

$$F = 2.490$$

4. Calculate the percent theoretical maximum specific gravity, **(%G_{mm})**, **G**, to the nearest 0.1% using the following formula:

$$G = \frac{D}{F} \times 100$$

where:

D = bulk specific gravity of briquette, G_{mb}
F = average theoretical maximum specific gravity, **G_{mm}**, of the mixture
100 = constant

example:

D = 2.389
F = 2.490

$$G = \frac{2.389}{2.490} \times 100$$
$$= 0.95943 \times 100$$
$$= 95.943$$
$$G = 95.9\ \%$$

5. Calculate the percent voids (V_a), **H**, to the nearest 0.1% using the following formula:

$$H = 100 - G$$

where:

G = percent theoretical maximum gravity (%G_{mm})
100 = constant

example:

G = 95.9%

$$H = 100 - 95.9$$
$$H = 4.1\%$$

6. Calculate the percent voids in mineral aggregate (%VMA), **J**, to the nearest 0.1% using the following formula:

$$J = 100 - \frac{(D \times P_s)}{G_{sb}}$$

where:

D = bulk specific gravity of briquette, **G_{mb}**
P_s = aggregate content, percent by total weight of mixture from JMF
G_{sb} = bulk specific gravity of the total aggregate from JMF
100 = constant

example:

D = 2.389
P_s = 95.5
G = 2.647

$$J = 100 - \frac{2.389 \times 95.5}{2.647}$$
$$= 100 - 86.2$$
$$J = 13.8\%$$

7. Calculate the percent voids filled with asphalt (%VFA), **K**, to the nearest whole percent using the following formula:

$$K = \frac{(J - H)}{J} \times 100$$

where:

H = percent voids
J = % voids in mineral aggregate
100 = constant

example:

H = 4.1
J = 13.8

$$K = \frac{(13.8 - 14.1)}{13.8} \times 100$$

$$= 0.7029 \times 100$$
$$= 70.28$$
$$K = 70\%$$

B. Pavement Core

1. Calculate the bulk specific gravity, **P**, of the pavement core to the nearest 0.001 using the following formula:

$$P = \frac{A}{C - B}$$

where:

A = wt. of core in air, g
B = wt. of core in water, g
C = wt. of core (SSD), g

example:

A = 737.5
B = 423.8
C = 739.4

$$P = \frac{737.5}{739.4 - 423.8}$$

$$= \frac{737.5}{315.6}$$

$$= 2.33681$$

$$P = 2.337$$

2. Calculate the %pavement density, **PD**, using the following formula:

$$PD = \frac{P}{G_{mm}} \times 100$$

where:

P = bulk specific gravity of pavement core, G_{mb}
G_{mm} = average maximum theoretical specific gravity for the lot
100 = constant

example:

P = 2.337
G_{mm} = 2.490

$$PD = \frac{2.337}{2.490} \times 100$$

$$= 0.93855 \times 100$$
$$= 93.855$$
$$PD = 93.9\%$$

3. Calculate the average % pavement density for the lot, **Avg PD**, using the following formula:

$$\text{Avg PD} = \frac{\sum PD_n}{N}$$

where:

PD_n = % pavement density of each core for the lot
N = number of cores for the lot

example:

PD_1 = 93.9
PD_2 = 93.9
PD_3 = 96.0
PD_4 = 95.7
PD_5 = 93.7
N = 5

$$PD_n = \frac{93.9 + 93.9 + 96.0 + 95.7 + 93.7}{5}$$

$$= \frac{473.2}{5}$$
$$= 94.640$$

$$PD_n = 94.6\%$$

VII. Report

A. Report all bulk specific gravity and maximum theoretical specific gravity results to the nearest 0.001.

B. Report the following results to the nearest 0.1.
   1. Percent Maximum Theoretical Specific Gravity
   2. Percent Voids
   3. Percent Voids in Mineral Aggregate (%VMA)
   4. Density of Mixture
   5. % Pavement Density

Note 3: *Approved forms other than Asphaltic Concrete Plant and Pavement Reports may be used to report density characteristics.*

VIII. Normal Test Reporting Time

Normal test reporting time is 2 days.

Figure 1
Molded Briquette Weighed In Water

MATT MENU SELECTION -- 04

2000 Specifications

DOTD 03-22-3085
Rev. 06/02

ASPHALTIC CONCRETE PLANT REPORT - (2000 Specifications)

English/Metric E (M / E) Spec Year 2000 <Entry Fields located on MATT Menu

Proj.No. 17B-02-0020 Plant H914 Mix Code 05

Proj.No. Seq. No. 043 Lot Number 424

Proj.No. Purp Code 3 No. Gradations

Proj.No. TSR, % Ten.Str.Control

Proj.No. Lot Size 2000 Act.Lot Tons (Mg)

Start Date Weather:

End Date Temp:High °F(°C) Low °F (°C)

PLANT TEST PROPERTIES (AASHTO T 166, T 209 & T 245 / DOTD TR's 304, 305 & 327)			1	2	3	4	AVERAGE
Wt (Mass) in Air	A		1209.3				
Wt (Mass) in Water	B		704.0				
Difference		A - B	505.3				
SSD Wt (Mass)	C		1210.2				
Bulk Sp Gr of Mix (G_{mb})	D	A / (C - B)	2.389				
Density	E	D x 62.4	149.1				
Theo Max Sp Gr (G_{mm})	F		2.490				
% Gmm	G	100 x D / F	95.9				
% Voids, V_a	H	100 - G	4.1				
% VMA	J	100 - (D x Ps) / Gsb	13.8				
% VFA	K	100 X (J - H) / J	70				
Dial Reading Marshall Test (AASHTO T245)							
Stability		From Chart					
Thickness							
Correction Factor							
Corrected Stability							
Flow 1/100							
Sample Taken Tons/Mg Accum.							
Temp of Mix °F							

DISCHARGE TEMPERATURE	TONS ACC.	ACT. TEMP.
JMF Limits:		
1		
2		
3		
4		
5		

% MOISTURE CONTENT (AGGR)	
% MOISTURE CONTENT (MIX)	

	TEST 1	TEST 2
% AC Met/Sc		
% Anti-Strip		
% Lime		

PERCENT PAY	
Stability	
Gradation	
Anti - Strip	

ASPHALT CONTENT	AM Check			PM Check		
	Asphalt	Aggr	RAP	Asphalt	Aggr	RAP
2nd Meter Reading						
1st Meter Reading						
Difference						
Corr.lbs of AC/Aggr						
% AC						

ANTI STRIP CONTENT	AM Check		PM Check	
	Asphalt	Anti Strip	Asphalt	Anti Strip
2nd Meter Reading				
1st Meter Reading				
Gallons				
Corr. Gal. at 60 °F				
Pounds Used				
% Anti Strip				

THEORETICAL MAXIMUM SPECIFIC GRAVITY, Gmm "RICE" (AASHTO T 209 or DOTD TR 327)

			Gmm1		Gmm2	
			Sample a	Sample b	Sample a	Sample b
Wt of Mix	A					
Wt of Pyc. & Water	D					
Wt of Pyc. Water & Mix	E					
Difference		A + D - E				
Gmm		A/(A + D - E)	Gmm 1a	Gmm 1b	Gmm 2a	Gmm 2b

Gmm1 = (Gmm1a + Gmm1b) / 2 = 2.486 Gmm2 = (Gmm2a + Gmm2b) / 2 = 2.494

Theo. Max. Sp. Gr Gmm = (Gmm1 + Gmm2) / 2 = 2.490

Ps (from JMF) 95.5
Gsb (from JMF) 2.647

$$Gse = \frac{100 - Pb}{\frac{100}{Gmm} - \frac{Pb}{Gb}} =$$

(Pb is % A.C., Gb = 1.03)

$$Pba = \frac{(100 \times Gb)(Gse - Gsb)}{Gsb \times Gse} =$$

$$Pbe = Pb - \frac{Pba \times Ps}{100} =$$

*** Note: Report Once per Lot ***

MATERIAL		SOURCE	COLD FEED, %	COLD FEED + RAP, %	MIX, %
Bin No. 1					
Bin No. 2					
Bin No. 3					
Bin No. 4					
Bin No. 5					
Bin No. 6					
RAP Aggr.					
RAP AC					
Asphalt	Grade				
			100 %		100 %

% AC BY EXTRACTION (DOTD TR 323)			TEST 1	TEST 2
Wt. (Mass) of Mix, Trays & Pan	M_T			
Wt. (Mass) of Trays & Pan	M_P			
Total Wt. (Mass) of Mix	M_S			
Correction Factor for Mix, %	CF			
Moisture Correction, % (TR 319)	MC	M_T - M_P		
Wt. (Mass) Loss, %	M_L			
AC Content, %	AC	(M_L - CF) or (M_L - CF - MC)		
Dry Total Wt. (Mass) of Aggr.	M			
Dry Wt. (Mass) After Wash, (TR 309)	X			
Decantation Loss	Y	M - X		
Accumulated Total	Z			
% Difference		(M - Z / M) (100)		
Sample Taken - Tons/Mg Accum				

Technician:

Inspector:

District Lab:

Approved By:

GRADATION OF EXTRACTED AGGREGATE (AASHTO T 30 or DOTD TR 309) - % CRUSHED (DOTD TR 306)

SIEVE		TEST NO. 1 WEIGHT (Mass)	%	% COARSER	% PASSING	DEV 1	TEST NO. 2 WEIGHT (Mass)	%	% COARSER	% PASSING	DEV 2
2 in. (50 mm)											
1 1/2 in. (3.75 mm)											
1 in. (25.0 mm)											
3/4 in. (19.0 mm)											
1/2 in. (12.5 mm)											
3/8 in. (9.5 mm)											
No. 4 (4.75 mm)											
No. 8 (2.36 mm)											
No. 16 (1.18 mm)											
No. 30 (600 μm)											
No. 50 (300 μm)											
No. 100 (150 μm)											
No. 200 (75 μm)											
Passing 200 (75 μm)			WT CRUSHED					WT CRUSHED			
Decant. Loss	Y		WT + 4 (4.75 mm)					WT + 4 (4.75 mm)			
Accum. Total	Z		% CRUSHED					% CRUSHED			

AVERAGES

Sieves	Average	Avg. Dev.	JMF Limits
2 in. (50 mm)			
1 1/2 in. (37.5 mm)			
1 in. (25.0 mm)			
3/4 in. (19.0 mm)			
1/2 in. (12.5 mm)			
3/8 in. (9.5 mm)			
No. 4 (4.75 mm)			
No. 8 (2.36 mm)			
No. 16 (1.18 mm)			
No. 30 (600 μm)			
No. 50 (300 μm)			
No. 100 (150 μm)			
No. 200 (75 μm)			
% AC			

% AC(Met/Sc) % AC- JMF

% Crushed Min.

Figure 2
Asphaltic Concrete Plant Report

MATT MENU SELECTION - 03

03/02

Louisiana Department of Transportation and Development

ASPHALTIC CONCRETE PAVEMENT REPORT - 2000 Specifications

Metric/English E (M/E) **Spec. Year** 2000 **< Entry Fields Located on MATT Menu**

Project No. 178-02-0020 **Plant Code** H914 **Mix Code** 05 **As** 05 **Mix Use** 01

Lot No. 424 **Purpose Code** 3 **Specification Code** 1 **Pavement Code** 01 **Sub Code** 0581

From Station ____ + ____ To Station ____ + ____ Location ____ Proj. Engr. ____

From Station ____ + ____ To Station ____ + ____ Location ____ Start Date ____

From Station ____ + ____ To Station ____ + ____ Location ____ End Date ____

From Station ____ + ____ To Station ____ + ____ Location ____ Adjustment Factor ____

Surface Tolerance (DOTD TR 641)

ACCEPTANCE TOLERANCE ____ Profile Index: A = 3.0 in/mi (47.0 mm/km) B = 5.0 in/mi (79.0 mm/km) D = 12.0 in/mi (189.0 mm/km) Straightedge: 5 = 5.0 in/mi (79.0 mm/km)

LINEAR, ft (m) ____ AVG. PROFILE INDEX, in/mi (mm/km) ____.__ IRI STD in/mil (mm/km) ____.__

Pavement Density (AASHTO T 166 or DOTD TR 304)

Sample No.	Date	Station	Thickness in (mm)	Wt. in Air (A)	Wt. in Water (B)	Wt. Surf Dry SSD (C)	Bulk Sp Gr (P) A / C - B	% Pav. Density (P/G_{mm} x 100)
				737.5	423.8	739.4	2.337	93.9
								93.9
								96.0
								95.7
								93.7
AVERAGE PAVEMENT DENSITY FOR LOT								94.6

Project Quantity tons (Mg)

Previous ____ + Portion of Lot Used (B) ____ = Total to Date ____

Yield

Area, sy (sm) (A) ____

Theor. Yield (lb/sy) ____.__

115 x Plan Thickness, in ÷ Adj. Factor

(2.46 x Plan Thickness, mm ÷ Adj. Factor)

Actual Yield (lb/sy) ____.__

Portion of Lot Used (B)
B x 2000 ÷ A
(B x 1000 ÷ A)

Theo. Max SG (G_{mm}) 2.490 *(per lot)*

Percent Pay

Density ____

Surface Tolerance ____

Pay Item ____

Rdwy Insp. ____

Remarks ____ **Plant Insp.** ____

Approved By ____

Figure 3
Asphaltic Concrete Pavement Report